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A Method of Determining Dot Sharpness of Lithographic Films

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A METHOD OF DETERMINING DOT SHARPNESS OF LITHOGRAPHIC FILMS

BY

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ABSTRACT

Two methods were attempted to determine an objective evaluation of lithographic films with respect to the sharpness of half-tone dots produced by the films. In Method I a step function target was placed in contact with a continuous wedge and a film sample. After exposure and development, a curve of the film was drawn in terms of per cent transmission versus log exposure. Since the input (target) is a step function, the output (curve) should also be a step function. It was expected that the width of the step in the curve would yield some measure of how well the film would produce hard dots. After curves for several films were drawn and examined, it was found that there was no difference between films.

Method II was conducted in a similar way as Method I but a different target was used. A line screen was used to expose a film in such a way that the lines ran parallel to the sample. The target was then turned ninety degrees and a second sample was exposed. After development, the film was analyzed to find a difference in curves caused by the target orientation. This difference was compared with the difference obtained with another film. No difference between the films was found.

INTRODUCTION

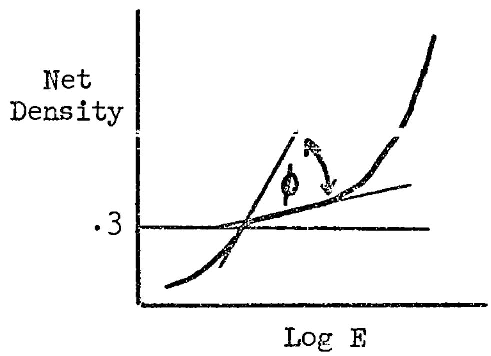
Because of the way lithographic films are used, normal H&D curves and image evaluation techniques are not as applicable as with other types of films. The lithographic films are used to form half-tone dots from continuous tone patterns. For this reason, it is desirable to evaluate a film by its ability to produce a hard dot. The quality of a photographic half-tone reproduction is determined by the quality of the half-tone dot which is generally expressed in terms of the sharpness of the dot in the fringe area. At present, the graphic arts technician generally must rely on subjective forms of evaluation such as viewing the dots with a magnifier. It is desirable to have the sharpness performance of the film expressed in objective terms that can be easily understood and unambiguously communicated. It was the purpose of this research to produce such a method.

BACKGROUND AND THEORY

Dr. G. W. Schumann, in an article entitled: "Sensitometry of High Contrast Graphic Arts Films"[1], has described the need to develop a sensitometric procedure for the evaluation of graphic arts films other than the commonly used H&D curve. "The understandable lack of agreement between the shape of H&D curves and practical experience has led to a situation where most of the testing relies on practical experience."[2] Furthermore, Dr. Schumann points out that any proposed alternative sensitometric process should yield more information about intrinsic emulsion properties. In this article, he has outlined such an alternative process.[3]

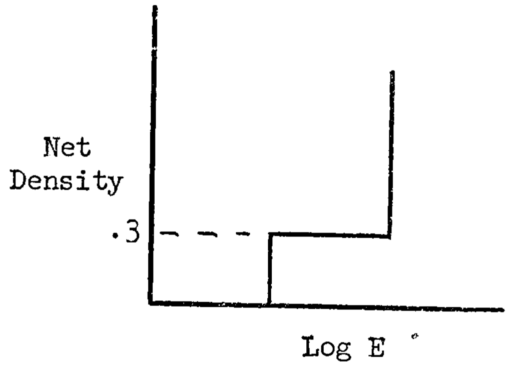
1. A ronchi ruling (133 lines / inch) of 50% bar area is placed in contact with the film and the film is then exposed through a step wedge.
2. When the processed film is evaluated in terms of large area density (densitometer aperture covering at least 10 line pairs) a density versus log exposure curve is obtained which has a form typical of that shown in Figure 1.

Figure 1.



This curve is referred to as the R-characteristic of the emulsion. When the critical exposure level is reached in the spaces of the crenelate pattern, 50% of the film will be exposed and its transmittance after processing to D_{max} will be 50% (density = 0.3). As the exposure level increases, eventually enough radiation penetrates the bars to expose this area of the film. At this point the film is totally exposed and its transmission after processing is simply 1/antilog D_{max}. An ideal high-contrast film would produce the R-characteristic shown in Figure 2.

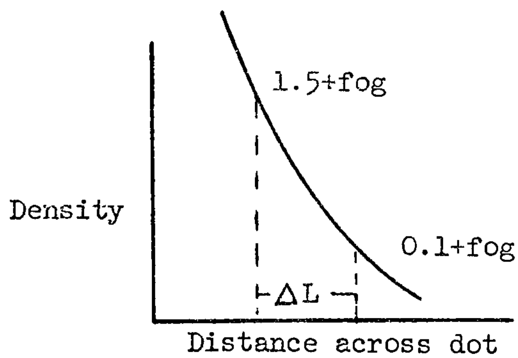
Figure 2.



Dr. Schumann concludes that the closer the R-characteristic approaches the ideal situation, then the better will be the dot quality (meaning higher sharpness). He then suggests that some geometrical property of the R-characteristic curve may yield a measure of dot sharpness. He specifically referred to the angle ϕ (Figure 1).

A method for measuring dot sharpness with a microdensitometer was proposed by Komatsu and Miyauchi.[4] A dot was traced and evaluated according to Figure 3.

Figure 3.



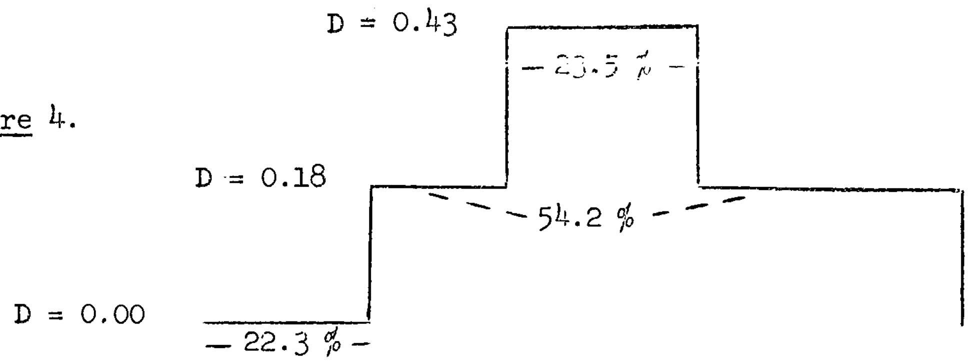
The densities of 0.1+fog and 1.5+fog were chosen as densities at which to measure the distance ΔL. The sharpness of the dot was expressed in terms of this distance. The smaller the distance, the sharper the dot.

It was desirable to incorporate both the sensitometric and the densitometric methods of evaluating lithographic films to obtain a simple, easy to conduct method that required only a conventional densitometer to analyze the samples. After the sensitometric tests were done on a film, the dots produced by that film were to be evaluated as suggested by Komatsu and Miyauche[5]. A numerical value could then be assigned to the sensitometric results. The sensitometric portion of the experiment was attempted using two different targets as described below.

METHOD I

Method I employed a target shown graphically in Figure 4.

Figure 4.



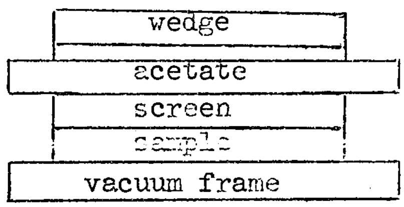
The target is periodic at 65 periods per inch. A microdensitometer trace across several periods yielded the following information:

% area of each step
base+fog - 22.3%
1st step - 54.2%
2nd step - 23.5%

Relative density of each step
base+fog - 0.00
1st step - 0.18
2nd step - 0.43

The target was placed in contact with a film sample on a vacuum frame as shown in Figure 5. An acetate cover sheet was used to vacuum the two components together. A continuous wedge was placed in a thin frame on the acetate cover sheet. The purpose of the frame was to prevent any interference patterns that might be caused from the wedge-acetate contact. The sample was then exposed with a tungsten bulb at a distance of five feet. Development was done by Kodalith developer at 72 °F. Nitrogen burst agitation was used for a period of 0.6 seconds every 10 seconds.

Figure 5.



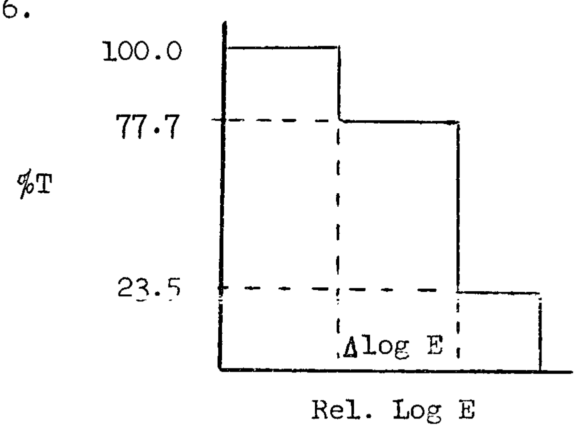
The films tested were 3M QA Lith, Iflord Formolith SP4, Dupont 710 Cronar, and GAF Lithofilm P407. The following film exposure combinations were found to give the best results for development times indicated:

1 ½ min.		2 min.	
GAF	- 15 sec.	GAF	- 5 sec.
Ilford	- 15 sec.	Ilford	- 5 sec.
Dupont	- 15 sec.	Dupont	- 5 sec.
3M	- 15 sec.	3M	-15 sec.

2 ½ min.		3 ¼ min.	
GAF	- 5 sec.	GAF	- 2 sec.
Ilford	- 5 sec.	Ilford	- 2 sec.
Dupont	- 5 sec.	Dupont	-2½ sec.
3M	-10 sec.	3M	- 7 sec.

The different exposure times were used to insure that the film would produce the full characteristic curve. The response of the film should be that shown in Figure 6.

Figure 6.



The first exposure to cause a drop in transmission goes through the B+F portion of the target which represents 22.3% of the target. Therefore, transmission should drop to 77.7% and level off until exposure through the 1st step is sufficient to cause a further drop in transmission which would level off at 23.5%. When exposure through the 2nd step is sufficient to cause a drop in transmission, the entire sample will be exposed and transmission will go to zero.

The variable to be measured is Δlog E as shown in Figure 6. Since the difference between B+F and the 1st step in the target is 0.18 density units, the Δlog E on the film sample should be 0.18.

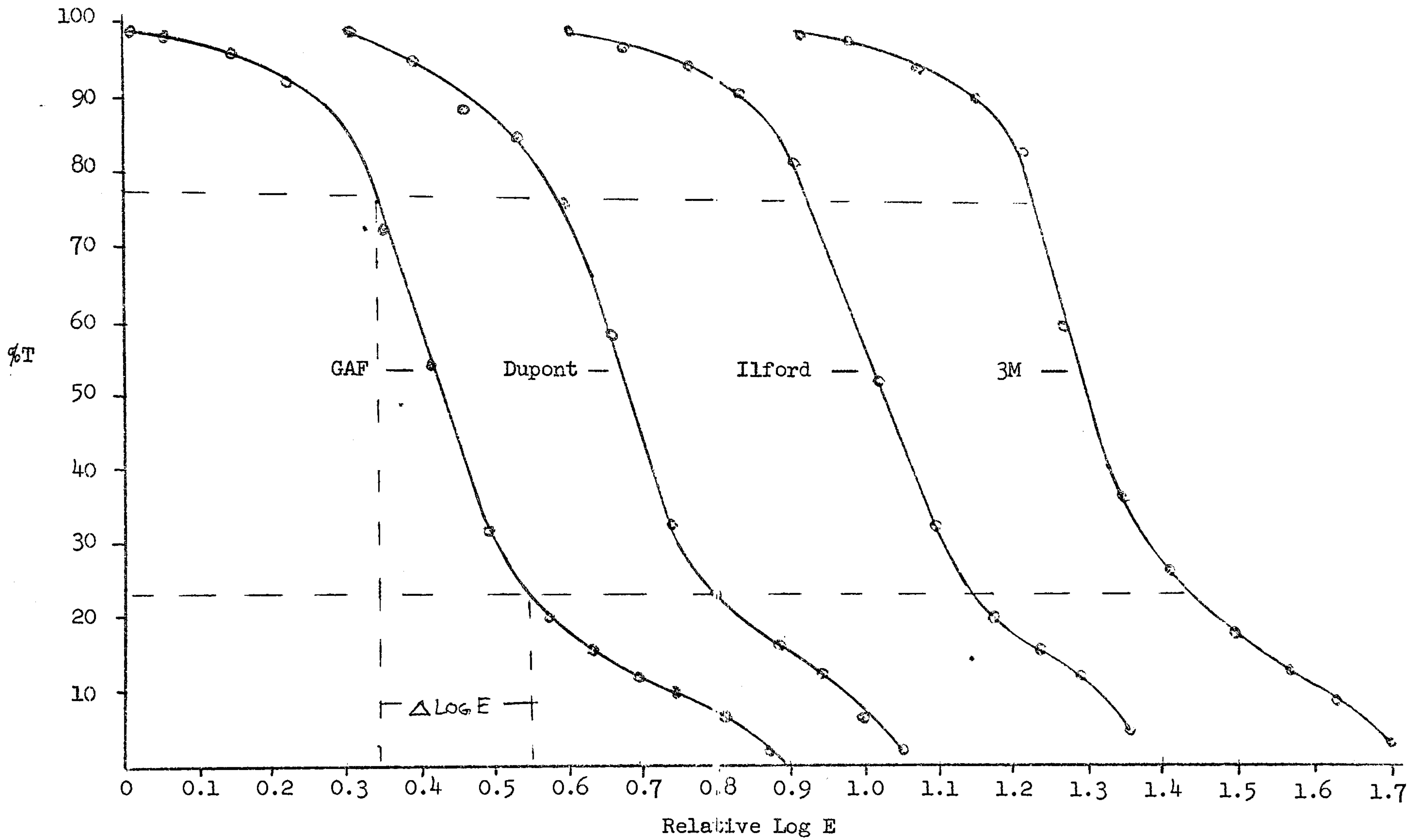
Because neither the film or the target is perfect, the curve is degraded. A microdensitometer trace of the target revealed that the vertical portions were not vertical but had a finite slope. This slope leads to curve degradation. The film possesses a toe and a finite slope instead of an infinite slope. These two characteristics also caused curve degradation. A final cause of curve degradation was that produced by the integrating effect of the densitometer aperture. For these reasons the points on the curve from which Δlog E was to be measured were quite difficult to determine. The Δlog E between the two theoretical transmission values shown in Figure 6 was used as a means of measuring the film response.

OBSERVATIONS AND CONCLUSIONS FOR METHOD I

Figure 7 shows one run at two minutes development time. This is the typical appearance of the curves obtained. The smearing of the curve is quite advanced due to the three reasons previously mentioned and the fact that the difference in target densities is quite low. It is expected that a larger density difference in the target would produce a more useful curve.

Three runs were made with one sample of each film in a run. Previous data showed that any variability within one run could be neglected. Data obtained from three runs are shown in Table 1.

2 MINUTE DEVELOPMENT



<u>Figure</u> 7. The films are drawn shifted laterally among themselves in order that a difference between them might be easier seen.

Table 1.

1 ½ min.

Film	$\bar{x}$	s
GAF	0.213	0.031
Dupont	0.233	0.040
Ilford	0.267	0.025
3M	0.263	0.057

2 min.

Film	$\bar{x}$	s
GAF	0.210	0.010
Dupont	0.197	0.086
Ilford	0.213	0.057
3M	0.200	0.010

2 ½ min.

Film	$\bar{x}$	s
GAF	0.207	0.057
Dupont	0.200	0.000
Ilford	0.190	0.057
3M	0.197	0.020

3 ¼ min.

Film	$\bar{x}$	s
GAF	0.203	0.015
Dupont	0.170	0.011
Ilford	0.190	0.017
3M	0.183	0.086

The mean Δlog E and standard deviation was computed for each sample and hypothesis tests for two sample averages were conducted on the extremes in each run. It can be stated with 95% confidence that there is no difference between samples. It must therefore be concluded that the proposed method of evaluating lithographic films is not useful when conducted in the manner of these tests. A similar target with greater density differences might yield useful information since a greater length of the Δlog E axis would be used. It would also be of great benefit to determine the smallest possible aperture that could be used to measure the transmission values without being affected by individual lines of density. The smallest integrating effect would be obtained and would produce a curve appearing more like the theoretical one.

METHOD II

Method II was conducted the same as Method I except a different target was used. The target was a lined screen with 65 lines per inch and 50% line. A film sample was exposed with the lines of the screen running parallel with the sample. A second sample of the same film was then exposed after the screen had been turned 90 degrees producing lines running across the sample. Due to the nature of infectious development, it was expected that development of the sample with lines running parallel to it would produce density farther down this sample than would its counterpart. The reason for the density difference is that an infectious developer has a great tendency to cause a grain next to a grain being developed to also be developed. The more exposure a normally undevelopable grain has, the easier it will be for that grain to be developed by an infectious developer. When a sample is exposed with the lines running parallel to it, each grain receives less exposure down the sample. A sample with lines running parallel to it forms a "bridge" of grains, each receiving less exposure, by which the developer can eventually develop every grain. A sample with lines running across it interrupts this "bridge" and development of less exposed grains takes a longer time. This difference between samples of one film was compared to the difference between samples of a second film in hopes of finding a difference between films which correlate to dot sharpness. Dupont and Ilford were chosen as test films. Three runs were made with the two exposures of each film in each run.

OBSERVATIONS AND CONCLUSIONS FOR METHOD II

The difference in density due to target orientation of one film was compared to that of the other by means of an hypothesis test for two sample averages. It can be stated with 95% confidence that there was no difference between films in any run.

SUMMARY

Two methods were utilized in an attempt to find a difference between films which might correlate with their ability to produce a hard dot. Neither method was successful but it must be remembered that a conventional densitometer was used to measure the results. There may have been differences between films capable of distinguishing one from another but not capable of being measured with a conventional densitometer. However, it was a purpose of this research to obtain a difference that such a densitometer could measure.

ACKNOWLEDGMENTS

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REFERENCES

1. G. W. Schumann, "Sensitometry of High Contrast Graphic Arts Films", J. Phot. Sci. & Eng., vol. 6, pp. 298-301; 1962.

2. Ibid., p. 298.

3. Ibid., p. 299.

4. M. Tajima, Y. Komatsu, and T. Miyauchi, "Techniques for Evaluating Dot Quality in Half-tone Processes", J. Phot. Sci. & Eng., vol. 8, p. 216; 1964.

5. Ibid., p. 216.

BIBLIOGRAPHY

1. G.W. Schumann, "Sensitometry of High Contrast Graphic Arts Films", J. Phot. Sci. & Eng., vol. 6, pp. 298-301; 1962

2. M. Tajima, Y. Komatsu, and T. Miyauchi, "Techniques for Evaluating Dot Quality in Half-Tone Processes", J. Phot. Sci. & Eng., vol. 8, pp. 216-221; 1964

3. Basic Photography for the Graphic Arts, Kodak Graphic Arts Data Book Q-1, Eastman Kodak Co., 1963

4. D.J. Howe and J.A.C. Yule, "Measurement of Dot Area and Sharpness", TAGA Prodeedings

5. H. Brent Archer, "Photometric Measurement of Dot Area", TATA Prodeedings

6. Kodak Photographic Materials for the Graphic Arts, Kodak Graphic Arts Data Book Q-2, Eastman Kodak Co., 1967

7. Mees And James, The Theory of the Photographic Process, 3rd edition, Macmillan, New York, 1966, p.367

8. R.E. Stauffer, W.F. Smith, and A.P. Trivelli, J. Franklin Inst., 238,291; 1944